Postconcussive Symptom Reporting Among U.S. Combat Veterans With Mild Traumatic Brain Injury From Operation Iraqi Freedom

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Objective: To examine the association between postconcussive symptoms and mild traumatic brain injury (MTBI) among combat veterans while adjusting for posttraumatic stress disorder (PTSD) and depression. **Patients:** Military personnel with provider-diagnosed MTBI ($n = 334$) or nonhead injury ($n = 658$) were identified from the Expeditionary Medical Encounter Database. **Main Outcome Measures:** Post-Deployment Health Assessments and Re-Assessments were used to examine postconcussive symptoms and self-rated health. **Results:** Personnel with MTBI were more likely to report headache (odds ratio [OR] = 3.37; 95% confidence interval [CI] = 2.19-5.17), back pain (OR = 1.79; 95% CI = 1.23-2.60), memory problems (OR = 1.86; 95% CI = 1.20-2.88), tinnitus (OR = 1.63; 95% CI = 1.10-2.41), and dizziness (OR = 2.13; 95% CI = 1.06-4.29) compared with those with non-head injuries. Among those with MTBI, self-reported decline in health was associated with memory problems (OR = 5.07; 95% CI = 2.56-10.02) and dizziness (OR = 10.60; 95% CI = 3.48-32.27). **Conclusions:** Mild traumatic brain injury is associated with reports of negative health consequences among combat veterans even when accounting for co-occurring psychological morbidity. The identification of postconcussive symptoms related to declines in a service member's self-rated health may be important in targeting and prioritizing clinical interventions. **Key words:** *combat*, *concussion*, *depression*, *mild traumatic brain injury*, *military*, *posttraumatic stress disorder*, *PTSD*

BLAST INJURIES account for a vast majority of all combat wounds in the current conflicts in Iraq and Afghanistan.[1–4] This is due, in part, to asymmetrical warfare techniques employed by the enemy, which include improvised explosive devices and other crude forms of blast weaponry. The preponderance of blast weaponry has resulted in an increased prevalence of concussion, or mild traumatic brain injury (MTBI) compared with previous 20th century military conflicts.[4,5] Furthermore, improvements in body armor and field medical care have resulted in a greater survivability rate and as such more personnel are surviving their wounds and are faced with adverse postinjury health sequelae.[5]

An array of negative health complaints have been reported following MTBI, including headache, dizziness, tinnitus, muscle aches, sleep problems, and cognitive deficits.[6–8] This cluster of complaints is often referred to as postconcussion syndrome (PCS), but because these symptoms are also known to occur among those with nonhead injuries,[9–11] psychiatric problems,[12,13] and even among healthy persons,[14] there is some controversy surrounding what constitutes a PCS diagnosis.

Examining the association between combat-related MTBI and PCS is further complicated by the austere environment in which the injury occurs. Military personnel with combat experiences have high rates of posttraumatic stress disorder (PTSD) and depression, and both of these disorders are associated with PCS symptoms.[13,15]

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Furthermore, persons with MTBI typically report higher rates of PTSD[16,17] and depression,[18,19] which presents the question as to whether PCS symptoms following MTBI are a product of the organic brain injury or subsequent mental health problems. Another potential mediator is blast injury mechanism, which has been suggested to have differential effects relative to nonblast mechanisms.[8]

Recent studies among military personnel have suggested that PCS symptoms following MTBI are strongly mediated by PTSD and depression.[17,20] After adjusting for PTSD and depression, Hoge et al[17] found that only headache was significantly higher among combat veterans with MTBI compared to those with other injuries. Similarly, Pietrzak et al[20] extended Hoge's findings by examining general health ratings and psychosocial functioning after MTBI and identified a strong mediating effect of PTSD. Both studies are limited, however, by the use of self-reported screening instruments to retrospectively identify personnel with MTBI.[21] Relying on patient recall can be problematic because MTBI is known to negatively affect memory.[22] Civilian studies have found that most MTBI symptoms resolve after 1 year.[23] Because most screening instruments used in previous military studies do not inquire about specific time of injury, many personnel in these studies may be screened for symptoms well after 1 year postinjury. Finally, the study by Hoge et al in part characterizes MTBI as an experience or event (eg, blast, motor vehicle accident) that left the person feeling "dazed or confused." This symptom is not specific to MTBI, but can also occur as a natural reaction to the stress of combat.[24]

The objective of the present analysis was to identify the association between MTBI and PCS symptoms among military personnel while accounting for the effects of PTSD and depression. By using in-theatre clinical records to identify MTBI, many of the limitations inherent with self-reported MTBI status were addressed. Specifically, the authors aimed to (1) compare PCS symptom reporting rates between MTBI and nonhead injuries after adjusting for PTSD and depression; (2) assess the potential mediating effects of loss of consciousness (LOC) among those with MTBI; and (3) identify the health complaints that contributed to declines in self-rated health among those with MTBI.

METHODS

Study sample

The Expeditionary Medical Encounter Database (EMED; formerly the Navy and Marine Corps Combat Trauma Registry) was queried for all personnel injured during Operation Iraqi Freedom who completed a Post-Deployment Health Assessment (PDHA) and a Post-Deployment Health Re-Assessment (PDHRA). This study was approved through the institutional review board at Naval Health Research Center (NHRC), San Diego, California.

The EMED is a deployment health database maintained by NHRC and consists of documented clinical encounters of deployed military service members.[25] Clinical EMED records are completed by health care providers stationed at forward-deployed Navy and Marine Corps military treatment facilities (eg, facilities located in Iraq to treat Operation Iraqi Freedom casualties). Unique aspects of the EMED include details of the injury event which are collected at or near the point of occurrence, as well as the inclusion of persons with milder injuries who are returned to duty. Clinical EMED records are then provided to NHRC where professional coders review the records and assign medical codes using the Abbreviated Injury Scale (AIS), Injury Severity Score (ISS), and *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*).[26–28] The AIS ranges from 1 (*minor*) to 6 (*unsurvivable*) and is assigned to 9 body regions. The ISS is a composite score based on the AIS and ranges from 1 to 75.

The PDHA and PDHRA are self-administered screening questionnaires developed by the Department of Defense to identify personnel in need of medical referral for a variety of health reasons.[29,30] The PDHA is given at the end of each deployment and the PDHRA is given after the service member has returned home, in part, to identify mental health symptoms that manifest on readjustment. Both surveys have been used in previous research to identify population level mental health screening rates.[31,32]

In this retrospective cohort study, the sample was identified from the EMED. The sample was further refined by restricting to service members who sustained *minor* to *moderate* injuries (ISS: 1-8) during Operation Iraqi Freedom between March 2004 and April 2008 and who completed a PDHA and PDHRA on completion of deployment. To ensure the effects of the MTBI were being measured, the sample was restricted to personnel completing both surveys within 1 year of the injury date. The final sample consisted of 992 injured personnel, with 334 sustaining MTBI and 658 sustaining a nonhead injury.

Measures

Covariates

Demographic variables included in the analysis were age, military rank, gender, and branch of service at the time of injury and were abstracted from the EMED clinical record and validated with information from the Defense Manpower Data Center, which maintains administrative records for all military personnel. Military rank was categorized as junior enlisted (E1–E3), mid-level

enlisted (E4–E6), and senior enlisted/officer. Branch of service was categorized into Marines, Army, and Navy/Air Force. Age was analyzed as a continuous variable.

Injury group, "MTBI" or "non-head injury," was identified from the EMED clinical record. As per previous literature,[33] MTBIs were identified through a 2-step process. First, all service members a TBI *ICD-9-CM* code in the range of 800.0 to 801.9, 803.0 to 804.9, or 850.0 to 854.1 were identified. Then, each TBI *ICD-9-CM* code was checked against the corresponding AIS severity score to ensure only TBIs with AIS values of 1 or 2 were included; only TBI *ICD-9-CM* codes with corresponding AIS values of 1 or 2 were considered MTBI. The non-head injury comparison group consisted of any injury where the head region was not specifically indicated as per AIS coding.

Type of injury was categorized as battle injury as a result of hostile action, or nonbattle, defined an injury resulting from nonhostile action. Injury type and presence/absence of blast mechanism were used to define injury mechanism as "battle, blast," "battle, nonblast," and "nonbattle." In logistic regression analysis, this variable was dichotomized into blast and nonblast. For persons with MTBI, LOC was identified from provider notes on the EMED clinical record.

Both the PDHA and EMED were used to approximate combat exposure. The PDHA contains questions that ask if the service member was exposed to dead bodies, discharged their weapon, or had a perceived threat to life. The specific questions are shown in Table 1. These 3 questions were incorporated together with presence/absence of battle injury (from the EMED record) to create a 4-level combat exposure measure. The final combat exposure variable was categorized into "0–1," "2," "3," and "4" to indicate the total number of combat exposures. Those endorsing all 3 combat exposure questions and sustaining a battle injury would be classified as having 4 combat exposures.

Mental health symptoms were ascertained from the PDHRA, which contains validated PTSD and depression screening instruments shown in Table 1. The 4-item PTSD screening instrument is based on the Primary Care PTSD screen.[34,35] Endorsing any 3 of the 4 symptoms indicates a positive screen for PTSD. The depression-screening tool was derived from the Patient Health Questionnaire and a positive screen is indicated by answering "more than half the days" or "nearly every day" to at least 1 of the 2 questions.[36]

Main outcome measures

Symptoms of PCS were identified from the PDHRA. On the PDHRA, the service member is presented a list of health complaints and asked to endorse whether they currently have a health concern or condition that they feel is related to their deployment. Current complaints of 9 PCS symptoms–headache, dizziness, memory problems, still feeling tired after sleeping (ie, sleep problems), back pain, joint and muscle pain, weakness, irritability and tinnitus–were abstracted from the PDHRA. A separate variable was created to indicate whether the service member endorsed 3 or more of these symptoms.

A measure of self-rated health was utilized to assess changes in the service member's perceived health status. On both the PDHA and PDHRA, the service member

TABLE 1 *Mental health and combat exposure questions from the Post-Deployment Health Assessment And Re-Assessment*

Posttraumatic Stress	Depression	Combat Exposure
Have you ever had any experience that was so frightening, horrible, or upsetting that, in the past month, you . . . ?	Over the past month, have you been bothered by the following problems?	Did you see anyone wounded, killed, or dead during this deployment? (yes/no)
Have had any nightmares about it or thought about it when you did not want to? (yes/no)	Little interest or pleasure in doing things (not at all/few or several days/more than half the days/nearly every day)	Were you engaged in direct combat where you discharged your weapon? (yes/no)
Tried hard not to think about it or went out of your way to avoid situations that remind you of it? (yes/no)	Feeling down, depressed, or hopeless (not at all/few or several days/more than half the days/nearly every day)	During this deployment, did you ever feel that you were in great danger of being killed? (yes/no)
Were constantly on guard, watchful, or easily startled? (yes/no)		
Felt numb or detached from others, activities, or your surroundings? (yes/no)		

is asked to rate their current health as excellent, very good, good, fair, or poor. A decline in self-rated health was defined as endorsing excellent, very good, or good health on the PDHA and endorsing fair or poor health on the PDHRA.

Statistical analysis

All statistical analyses were performed using SAS version 9.2 (Cary, North Carolina). Demographics, injury-specific information, self-reported combat exposure, and mental health problems were described for the study sample by MTBI status. The association between MTBI and PCS symptoms was shown using unadjusted odds ratios and odds ratios adjusted for other potential confounders. Separate models were run with each PCS symptom as the dependent variable, as well as one model with 3 or more symptoms as the outcome. A separate analysis was performed among those with MTBI exploring the mediating effect of LOC on reporting of PCS symptoms. The analysis of decline in self-rated health was restricted to personnel with MTBI who endorsed good to excellent health on the PDHA. Predictors of a decline in health were examined using backward selection logistic regression modeling and assessed the PCS and mental health symptoms associated with MTBI. Model fit was assessed with the Hosmer-Lemeshow test for all final multivariate logistic regression models at an alpha level of 0.10. Chi-square and 2 sample *t* tests were used to examine categorical and continuous variables, respectively.

RESULTS

The study sample consisted of 334 service members with MTBI and 658 with nonhead injuries. Of those with MTBI, 92 had concussion with LOC of 30 minutes or less (*ICD-9-CM* 850.11), 1 had concussion with LOC of 31 to 59 minutes (850.12), 10 had concussion with LOC of unspecified duration (850.5), 150 had concussion with no LOC (*ICD-9* 850.0), and 81 had MTBI characterized as "concussion, unspecified"(850.9). Characteristics of the study sample by MTBI status are shown in Table 2. Compared with nonhead injuries, those with

TABLE 2 *Characteristics of the study sample (N = 992)*

Characteristic	MTBI (*n* = 334)	Nonhead Injury (*n* = 658)	*P*
Sex, *n* (%)[a]			<.001
Female	1 (0.3)	45 (6.8)	
Male	333 (99.7)	613 (93.2)	
Mean age (range), y[b,c]	23.3 (18-45)	25.3 (18-57)	<.001
Rank, n (%)[a,d]			<.001
Junior enlisted (E1-E3)	178 (53.3)	239 (36.6)	
Midlevel enlisted (E4-E6)	139 (41.6)	346 (53.0)	
Senior enlisted and officers	17 (5.1)	68 (10.4)	
Service branch, n(%)[a]			<.001
Marines	233 (69.8)	337 (51.2)	
Army	78 (23.4)	252 (38.3)	
Other	23 (6.9)	69 (10.5)	
Mechanism of injury, n(%)[a]			<.001
Battle, blast	297 (88.9)	274 (41.6)	
Battle, nonblast	8 (2.4)	61 (9.3)	
Nonbattle	29 (8.7)	323 (49.1)	
Mean ISS ± SD[c]	2.8 ± 1.7	1.5 ± 1.1	<.001
Combat exposures, *n* (%)[a,e]			<.001
0-1	26 (7.8)	231 (35.2)	
2	42 (12.6)	102 (15.5)	
3	100 (29.9)	133 (20.2)	
4	166 (49.7)	191 (29.1)	
Mental health problems, *n* (%)			
PTSD[a]	93 (27.8)	113 (17.2)	<.001
Depression[a]	69 (20.7)	87 (13.2)	.002
Mean days injury to PDHRA ± SD[c]	249.2 ± 56.6	258.6 ± 61.4	.019

Abbreviations: ISS, Injury Severity Score; PDHRA, Post-Deployment Health Re-Assessment; PTSD, posttraumatic stress disorder; SD, standard deviation; MTBI, mild traumatic brain injury.
[a] χ^2 test.
[b] $n = 2$ (missing data).
[c] 2 sample *t* test.
[d] $n = 5$ (missing data).
[e] $n = 1$ (missing data).

TABLE 3 *Unadjusted and adjusted odds ratios for postconcussive symptoms by mild traumatic brain injury status (N = 992)*

	MTBI (*n* = 334)		Nonhead Injury (*n* = 658)		Unadjusted		Adjusted for Demographic and Injury Variables[a]		Adjusted for PTSD, Depression, and Other Variables[b]	
Symptom	***n***	**%**	***n***	**%**	**OR**	**95% CI**	**OR**	**95% CI[c]**	**OR**	**95% CI[c]**
Weakness	18	5.4	22	3.3	1.65	0.87-3.12	1.59	0.74-3.39	1.41	0.64-3.08
Headache	111	33.2	75	11.4	3.87	2.78-5.39[d]	3.29	2.19-4.93[d]	3.37	2.19-5.17[d]
Sleep problems	118	35.3	130	19.8	2.22	1.65-2.98[d]	1.45	1.02-2.08[f]	1.36	0.90-2.06
Back pain	110	32.9	139	21.1	1.83	1.37-2.46[d]	1.86	1.30-2.69[d]	1.79	1.23-2.60[e]
Muscle/joint pain	78	23.4	126	19.1	1.29	0.94-1.77	1.14	0.77-1.68	1.05	0.71-1.57
Memory problems	95	28.4	88	13.4	2.58	1.86-3.57[d]	1.93	1.30-2.87[e]	1.86	1.20-2.88[e]
Tinnitus	116	34.7	118	17.9	2.44	1.80-3.29[d]	1.70	1.19-2.45[e]	1.63	1.10-2.41[f]
Dizziness	34	10.2	21	3.2	3.44	1.96-6.03[d]	2.40	1.23-4.66[f]	2.13	1.06-4.29[f]
Irritability	99	29.6	106	16.1	2.19	1.60-3.00[d]	1.49	1.02-2.18[f]	1.37	0.89-2.10
≥3 symptoms	137	41.0	147	22.3	2.42	1.82-3.21[d]	1.70	1.21-2.41[e]	1.67	1.13-2.46[f]

Abbreviations: 95% CI, 95% confidence interval; OR, odds ratio; PTSD, posttraumatic stress disorder; MTBI, mild traumatic brain injury.
[a] Adjusted for age, Injury Severity Score, combat blast mechanism, and combat exposure.
[b] Adjusted for age, Injury Severity Score, combat blast mechanism, combat exposure, posttraumatic stress disorder, and depression.
[c] Hosmer-Lemeshow test indicated a good fit for all multivariate models ($P > .10$).
[d] $P < .001$.
[e] $P = .001$ to .009.
[f] $P = .01$ to $< .05$.

MTBI were more likely to be male, younger, junior enlisted and Marines. Blasts accounted for more than twice as many MTBIs (88.9%) than nonhead injuries (41.6%), and personnel sustaining an MTBI had more severe injuries overall. Response time to the PDHRA differed between groups, with means of 249.2 days and 258.6 days for MTBI and nonhead injuries, respectively ($P = .019$). Those with MTBI reported higher levels of combat exposure, with 29.9% and 49.7% reporting 3 and 4 exposures, respectively, compared with only 20.2% and 29.1% among those with nonhead injuries. There were increased rates of mental health symptoms among personnel with MTBI compared with nonhead injuries, with higher screen positive rates for both PTSD (27.8% vs 17.2%, $P < .001$) and depression (20.7% vs 13.2%, $P = .002$).

Table 3 details the rates of PCS symptoms for MTBI and nonhead injuries and shows the results of logistic regression analysis. In univariate analysis, all symptoms, with the exception of weakness and muscle/joint pain, were significantly higher among those with MTBI. These results were consistent after adjusting for age, ISS, blast mechanism, and combat exposure. After adjustment for PTSD and depression, significant associations remained for headache (odds ratio [OR] = 3.37; 95% confidence interval [CI] = 2.19-5.17), back pain (OR = 1.79; 95% CI = 1.23-2.60), memory problems (OR = 1.86; 95% CI = 1.20-2.88), tinnitus (OR = 1.63; 95% CI = 1.10-2.41), and dizziness (OR = 2.13; 95% CI = 1.06-4.29). Persons with MTBI were also more likely than those with nonhead injury to report 3 or more PCS symptoms after adjusting for PTSD, depression, and other covariates (OR = 1.67; 95% CI = 1.13-2.46).

A subgroup analysis was conducted for personnel with MTBI who had documented LOC information, and results are shown in Table 4. Overall, LOC status was determined for 75.7% of those with MTBI (253/334). Of the PCS symptoms, only memory problems (34.0% vs 20.7%, $P = .018$) and irritability (35.0% vs 23.3%, $P = .043$) were significantly higher in those with a confirmed LOC. Rates of depression and PTSD were not significantly different between LOC groups.

The analysis of decline in self-rated health was restricted to personnel that endorsed good, very good, or excellent health on the PDHA; those who endorsed fair or poor health on the PDHA or who did not respond to the self-rated health question on either the PDHA or PDHRA were excluded. Overall, 23.8% (69/290) of those with MTBI declined in self-rated health, which was significantly higher than the 17.3% (101/585) of nonhead injuries who experienced a decline ($P = .022$). The above-mentioned PCS symptoms associated with MTBI were assessed with PTSD and depression to determine the greatest contributors to a decline in self-rated health, and results are shown in Table 5. In univariate analysis, all PCS and mental health symptoms were associated with a decline in health. Following backward selection regression modeling, however, only the

TABLE 4 *Mental health problems and postconcussive symptoms among persons with MTBI with or without loss of consciousness (n = 253)*

Variable	MTBI With Loss of Consciousness (*n* = 103), *n* (%)	MTBI Without Loss of Consciousness (*n* = 150), *n* (%)	*P*[a]
Mental health problem			
PTSD	27 (26.2)	36 (24.0)	.689
Depression	21 (20.4)	31 (20.7)	.957
Postconcussive symptom			
Weakness	5 (4.9)	8 (5.3)	.865
Headache	37 (35.9)	43 (28.7)	.223
Sleep problems	36 (35.0)	50 (33.3)	.790
Back pain	31 (30.1)	49 (32.7)	.666
Muscle/joint pain	25 (24.3)	27 (18.0)	.225
Memory problems	35 (34.0)	31 (20.7)	.018
Tinnitus	37 (35.9)	48 (32.0)	.516
Dizziness	10 (9.7)	12 (8.0)	.636
Irritability	36 (35.0)	35 (23.3)	.043
≥3 symptoms	43 (41.7)	55 (36.7)	.415

Abbreviations: MTBI, mild traumatic brain injury; PTSD, posttraumatic stress disorder.
[a] χ^2 test.

effects of depression (OR = 2.73; 95% CI = 1.27-5.87), memory problems (OR = 5.07; 95% CI = 2.56-10.02), and dizziness (OR = 10.60; 95% CI = 3.48-32.27) remained significantly associated with self-reported health decline.

DISCUSSION

Mild traumatic brain injury is a preeminent wound of the current wartime environment. Consistent with previous literature, we found that a majority of

TABLE 5 *Unadjusted and adjusted odds ratios for mental health problems and postconcussive symptoms by decline in self-rated health among those with mild traumatic brain injury (n = 290)*

	Decline in Health (*n* = 69)		No Decline in Health (*n* = 221)		Unadjusted		Adjusted for Demographic and Injury Variables[a]	
Symptoms	*n*	%	*n*	%	OR	95% CI[b]	OR	95% CI[b]
PTSD	36	52.2	40	18.1	4.94	2.75-8.85[c]	NS	. . .
Depression	30	43.5	25	11.3	6.03	3.21-11.35[c]	2.73	1.27-5.87[e]
Back pain	30	43.5	56	25.3	2.27	1.29-3.99[d]	NS	. . .
Headache	42	60.9	52	23.5	5.06	2.85-8.98[c]	NS	. . .
Tinnitus	36	52.2	59	26.7	3.00	1.71-5.24[d]	NS	. . .
Memory problems	44	63.8	36	16.3	9.04	4.93-16.60[c]	5.07	2.56-10.02[c]
Dizziness	23	33.3	5	2.3	21.60	7.80-59.78[c]	10.60	3.48-32.27[c]

Abbreviations: 95% CI, 95% confidence interval; NS, not selected in backward stepwise elimination; OR, odds ratio; PTSD, posttraumatic stress disorder.
[a] Backward stepwise regression utilized and adjusted for age, Injury Severity Score, combat exposure, and combat blast mechanism.
[b] Hosmer-Lemeshow test indicated a good model fit for the final multivariate model ($P > .10$).
[c] $P < .001$.
[d] $P = .001$ to .009.
[e] $P = .01$ to $<.05$.

MTBIs are the result of blasts,[1–4] and are associated with postdeployment psychological morbidity.[17] Even after taking the psychological symptoms of PTSD and depression into account, other physical and neurological symptoms were found to be elevated in MTBI compared with nonhead injuries. This may reflect the manifestation of a distinct postconcussion syndrome that occurs in parallel with psychological symptoms. Identification and treatment of these symptoms, particularly those associated with lower self-rated health, is paramount in the rehabilitation of MTBI patients.

The primary finding of this study was the increased odds of headache, back pain, memory problems, tinnitus, and dizziness among combat veterans with MTBI after adjustment for PTSD and depression. This finding suggests that MTBI is an independent predictor of multiple PCS symptoms. This finding is in contrast to a recent study by Hoge et al that found only headache was elevated in MTBI compared with non-MTBI in a similar multivariate analysis.[17] The lack of comparable findings may be a result of methodological differences between the 2 studies. In this study, we used provider-diagnosed MTBI and restricted follow-up time to 1-year postinjury, whereas the Hoge et al study used self-report MTBI with limited knowledge of when the injury actually occurred. Our findings did suggest a role of psychological symptoms in presentation of PCS, as some of the associations between MTBI and PCS symptoms were attenuated after adjustment for PTSD and depression. The mediating effect of psychological symptoms in the persistence of PCS symptoms beyond 1 year was not examined in this analysis and needs further investigation, although one recent study suggested PCS symptoms beyond 1-year were largely mediated by PTSD.[37]

Another finding of interest was the independent associations of depression, memory problems, and dizziness with a decline in self-rated health among MTBI. With the array of symptoms that can occur following MTBI, identification of the symptoms that most impact a service-member's health may be important in targeting clinical interventions to maximize rehabilitation efforts. Both dizziness and memory problems have been implicated previously as reasons for lower return to work rates and life satisfaction among those with MTBI.[38,39] A recent study by Bombardier et al[40] found that among those with MTBI, comorbid major depressive disorder was an independent predictor of lower quality-of-life scores.[40] More research on these symptoms and how they affect long-term treatment and rehabilitation outcome is warranted.

A mediating effect of LOC was found with irritability and memory problems, but no other PCS symptoms. The effect of LOC has recently been debated in the literature, with some studies showing no exacerbating effects of LOC beyond the acute phase of MTBI, typically defined as 2 weeks postinjury.[41] The role of LOC in MTBI outcome needs to be further defined, with future research focusing on long-term influence on patterns of mental health and neurological disorders.

This study had several strengths relative to previous research. The aforementioned methodological differences, particularly the use of clinical records to ascertain MTBI status, were a key aspect of the study and may have minimized the effects of misclassification and recall bias. In addition to the presumed reduction in bias, these clinical records contained point of injury indicators which allowed for the incorporation of and adjustment for injury severity, a variable previously found associated with adverse psychological outcomes in military personnel.[42] Finally, knowledge of the actual date of injury permitted the one-year restriction on PCS symptom ascertainment, thus limiting the follow-up period to best approximate organic effects of the MTBI.

There were limitations that warrant mention. The EMED consists of data collected at Navy and Marine Corps medical facilities, thus members of other services are likely underrepresented. In addition, although all service members with MTBI in this study met the inclusion criteria, it is possible that some diagnosed with "concussion with loss of consciousness of unspecified duration" or "concussion, unspecified" may not meet other definitions of MTBI based on duration of LOC. Furthermore, the PDHRA ascertained symptoms with a simplistic presence/absence query, whereas some symptoms such as memory problems may be best evaluated using cognitive testing. Similarly, the instruments used to assess PTSD and depression were based on clinical screening tools not necessarily developed for population level screening, though the PTSD instrument was recently validated against the more widely used 17-item PTSD checklist.[35] It is also important to note that the PDHA and PDHRA are voluntary, thus noncompliance may limit generalizability.

Service members with MTBI are at risk for an array of adverse PCS symptoms that may potentially affect clinical, rehabilitative, vocational, and quality-of-life outcomes. The long-term persistence of these symptoms needs to be investigated, possibly by incorporating repeated measurements of PCS symptoms over time. Because many of these symptoms are also associated with PTSD and depression, these conditions need to be studied concurrently. As MTBI continues to cause significant morbidity among US military personnel, research initiatives should focus on identifying target areas for neurological and psychological care to foster postdeployment readjustment.

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14. ABSTRACT

Objective: To examine the association between postconcussive symptoms and mild traumatic brain injury (MTBI) among combat veterans while adjusting for posttraumatic stress disorder (PTSD) and depression. **Patients**: Military personnel with provider-diagnosed MTBI (*n* = 334) or non-head injury (*n* = 658) were identified from the Expeditionary Medical Encounter Database. **Main Outcome Measures:** Post-Deployment Health Assessments and Reassessments were used to examine postconcussive symptoms and self-rated health. **Results**: Personnel with MTBI were more likely to report headache (odds ratio [OR] = 3.37; 95% confidence interval [CI], 2.19–5.17), back pain (OR = 1.79; 95% CI, 1.23–2.60), memory problems (OR = 1.86; 95% CI, 1.20–2.88), tinnitus (OR = 1.63; 95% CI, 1.10–2.41), and dizziness (OR = 2.13; 95% CI, 1.06–4.29) compared with those with non-head injuries. Among those with MTBI, self-reported decline in health was associated with memory problems (OR = 5.07; 95% CI, 2.56–10.02) and dizziness (OR = 10.60; 95% CI, 3.48–32.27). **Conclusions**: MTBI is associated with reports of negative health consequences among combat veterans even when accounting for co-occurring psychological morbidity. The identification of postconcussive symptoms related to declines in a service member's self-rated health may be important in targeting and prioritizing clinical interventions.

15. SUBJECT TERMS
MTBI, health complaints, military

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